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(54) **METHOD OF FABRICATING A REINFORCING EDGE FOR A BLADE AND REINFORCING EDGE OBTAINED BY THE METHOD**

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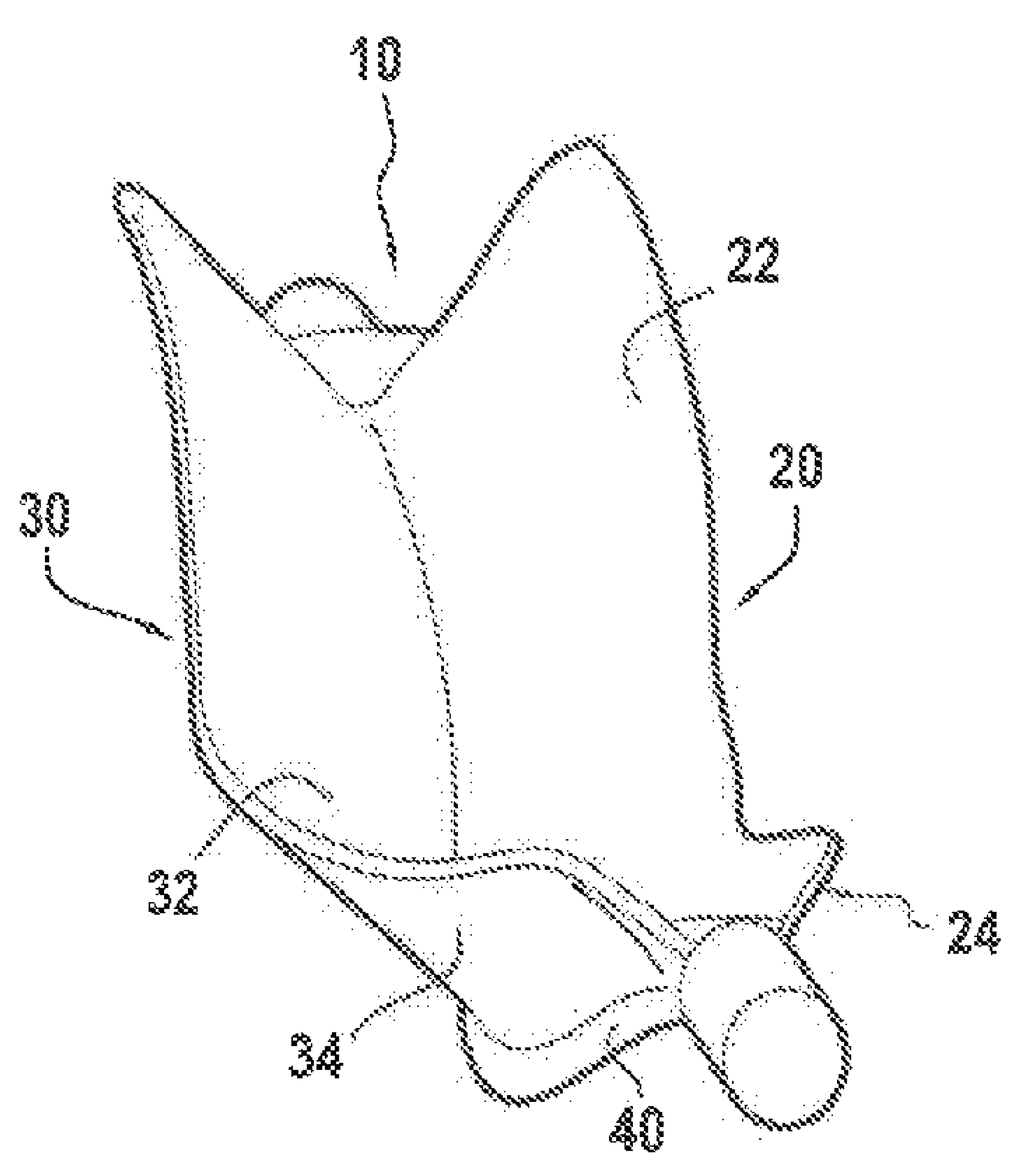
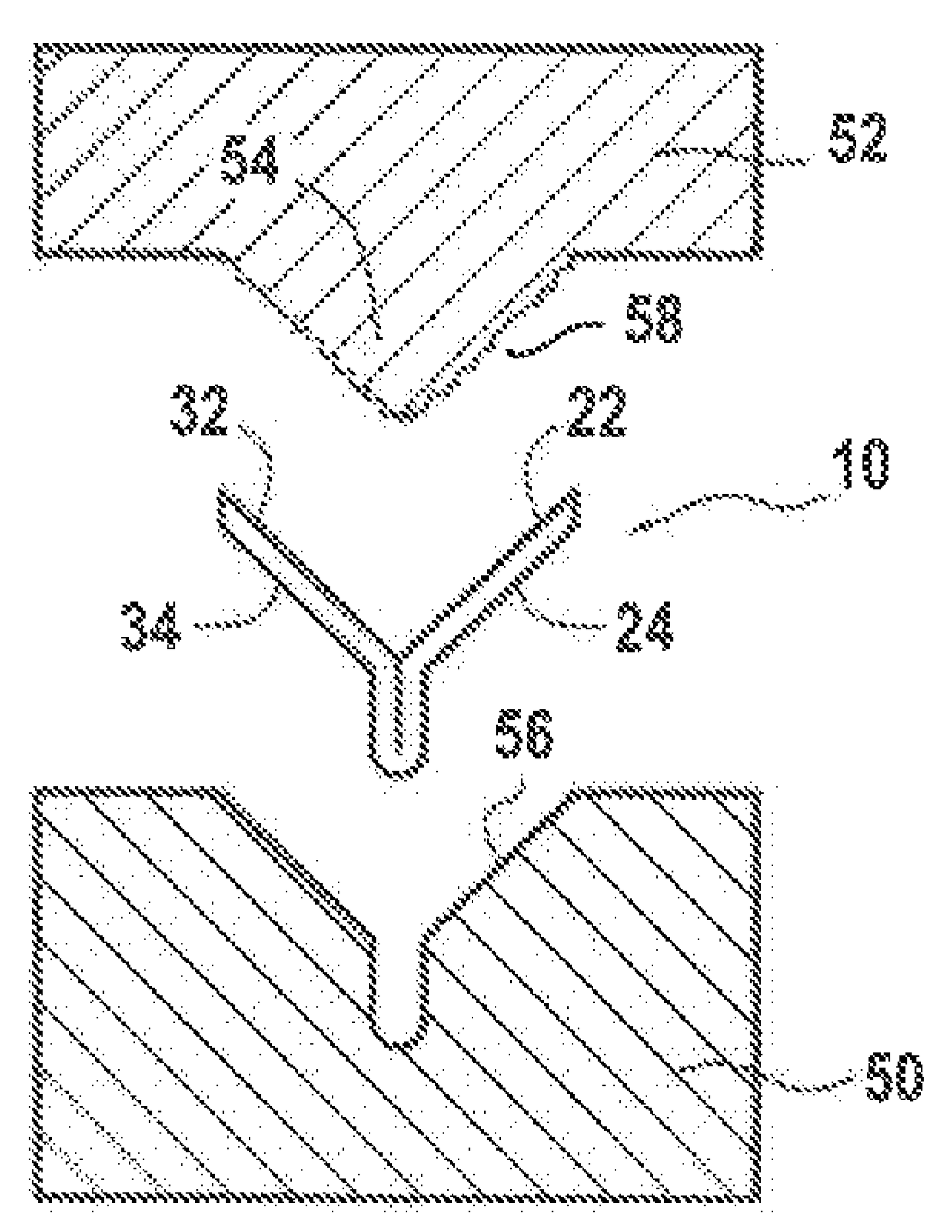
(57) **ABSTRACT**

A method of fabricating a reinforcing edge (**10'**) of a turbine engine blade (**70**) in which there is provided a blank (**10**) of the reinforcing edge and an indentation is imprinted in said blank so as to form a rough surface (S). A reinforcing edge (**10'**) obtained by such a method.

13 Claims, 1 Drawing Sheet





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See application file for complete search history.

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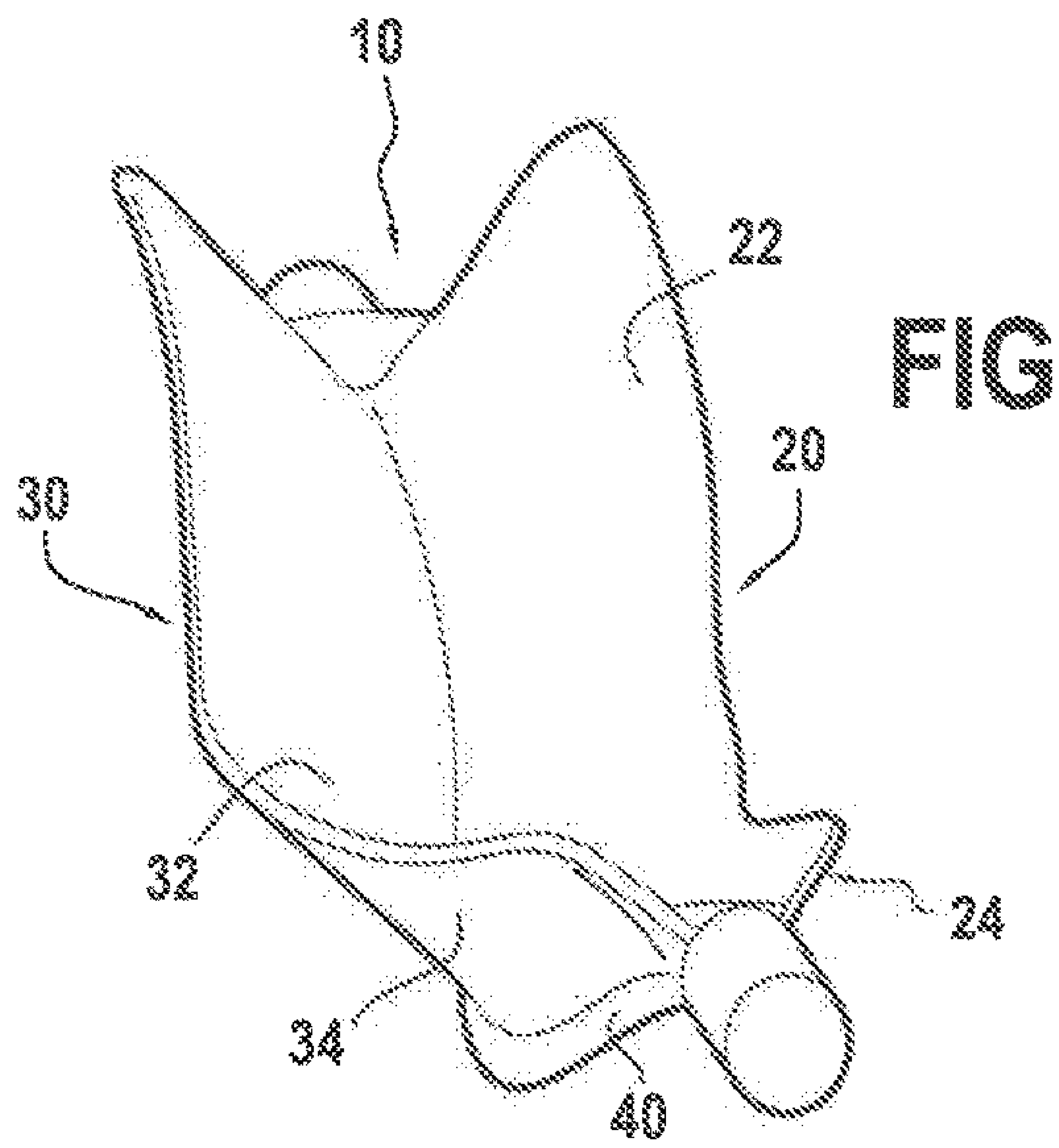

FIG.1

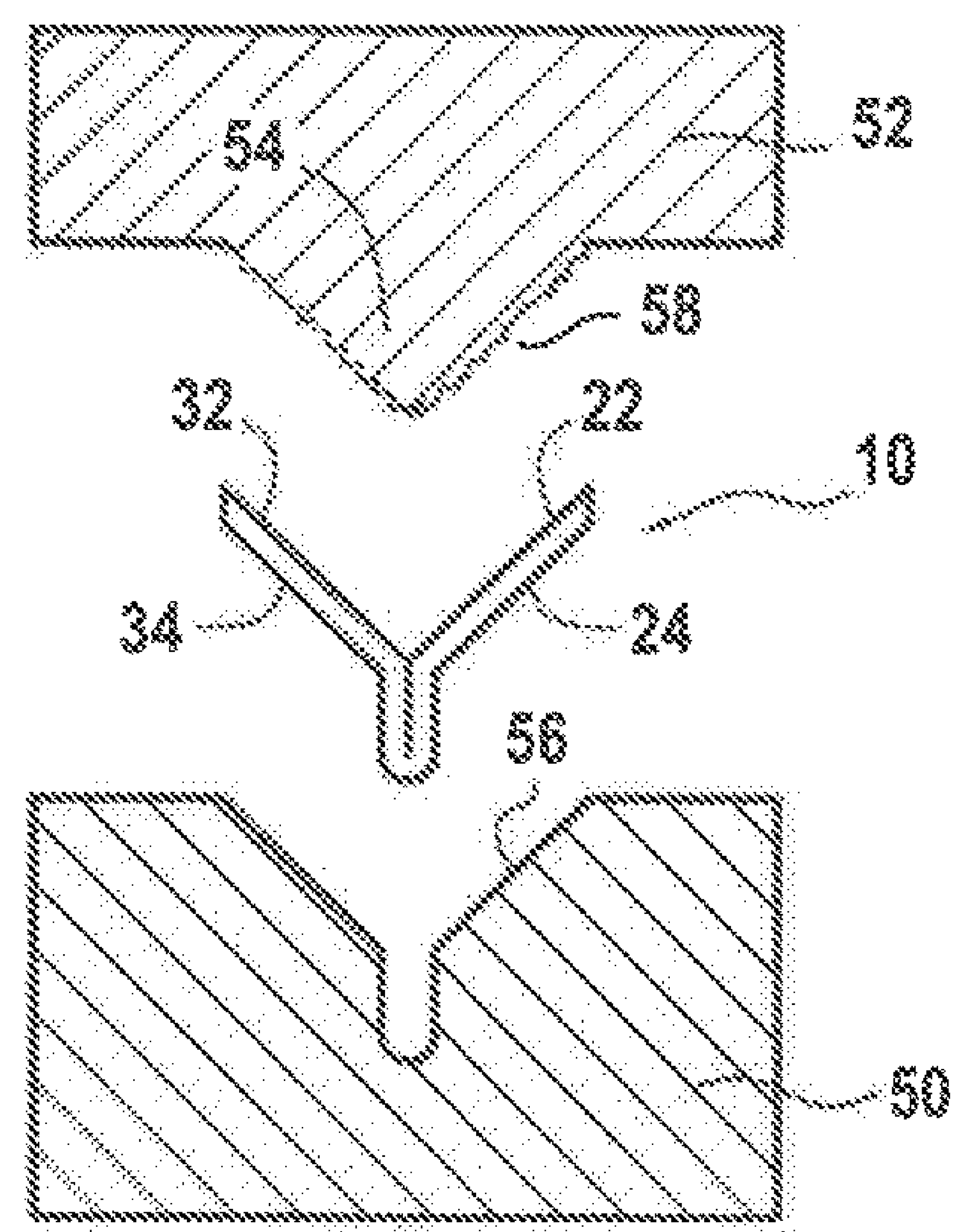

FIG.2

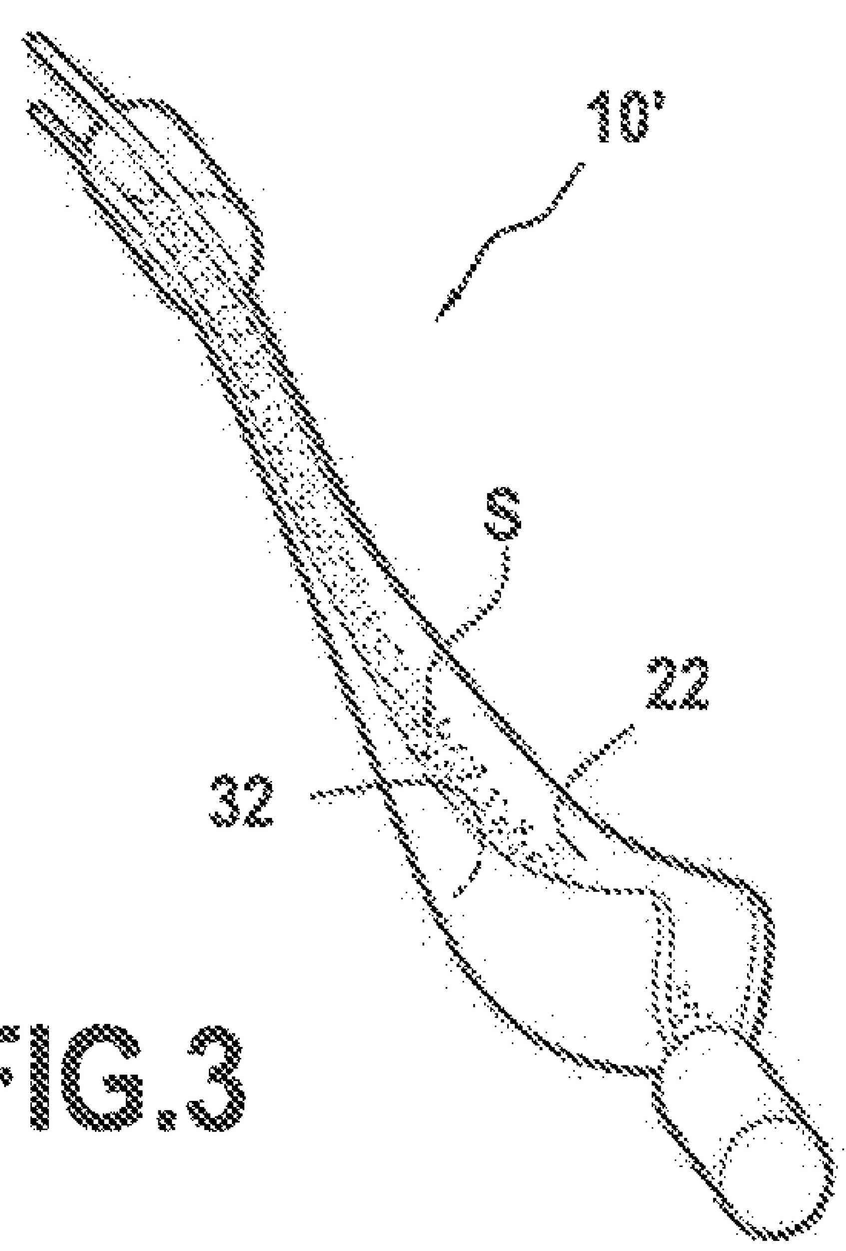

FIG.3

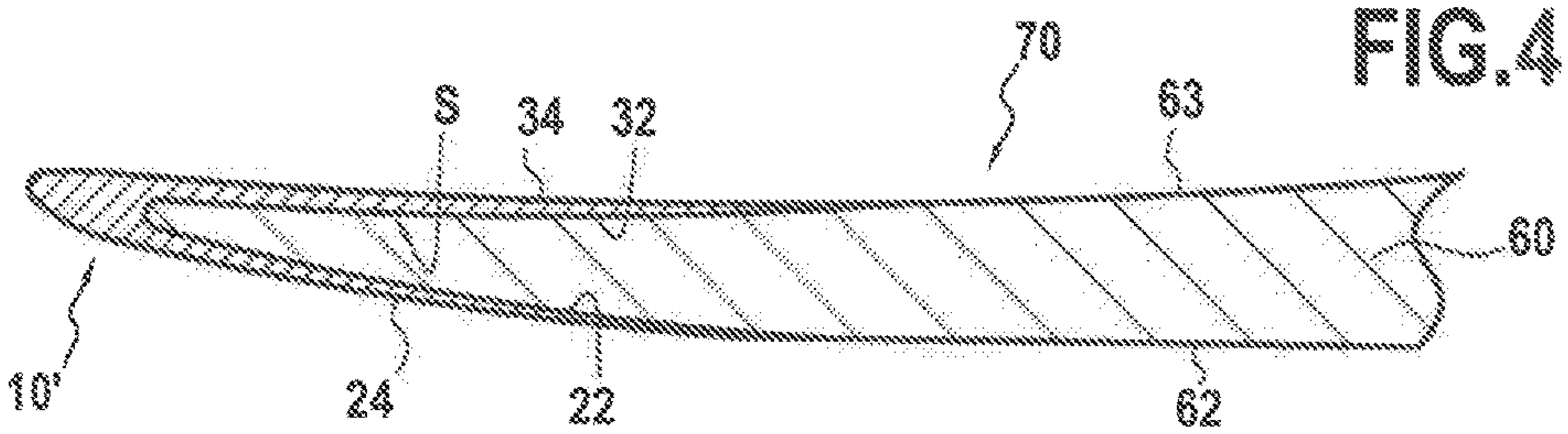

FIG.4

METHOD OF FABRICATING A REINFORCING EDGE FOR A BLADE AND REINFORCING EDGE OBTAINED BY THE METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. national phase entry under 35 U.S.C. § 371 of International PCT Application No. PCT/FR2014/052112, filed on Aug. 22, 2014, which claims priority to French Patent Application No. FR 1358272, filed on Aug. 29, 2013, the entireties of each of which are incorporated by reference herein.

FIELD OF THE INVENTION

The present description relates to a method of fabricating a part and to a part obtained by the method.

More particularly, said part may be a reinforcing edge for a turbine engine blade. Such a reinforcing edge may be fitted to any type of terrestrial or aviation turbine engine, and in particular to a helicopter turboshaft engine or to an airplane turbojet engine.

BACKGROUND OF THE INVENTION

Turbine engine blades are subjected to high levels of mechanical stress, associated in particular with their speed of rotation, while also being required to satisfy strict conditions concerning weight and size. One of the options envisaged for lightening blades is to use a composite material for fabricating them. Nevertheless, turbine engine blades must also satisfy severe utilization criteria, and in particular they must withstand abrasion and impacts against foreign bodies. For example, a front fan blade of an airplane turbojet must withstand abrasion in flight and must also withstand impacts against birds struck in flight. Unfortunately, when the leading edge of a blade is made of the same composite material as the body of the blade, the leading edge runs the risk of presenting insufficient resistance to abrasion or to impacts.

In order to resolve this problem, proposals have been made to consolidate the leading edge of a blade by fitting a separate part on the body of the blade, which part becomes incorporated in the aerodynamic profile of the blade. Such a separate part is referred to as a reinforcing edge.

A reinforcing edge is generally a solid part extending longitudinally along a substantially radial direction relative to the axis of rotation of the engine, and in cross-section it presents a profile that is generally Y-shaped, with a central portion of considerable thickness between tapering branches. The reinforcing edge thus presents a longitudinal central portion of considerable thickness, referred to as a "nose", lying between thin longitudinal flanks.

The thickness of such a reinforcing edge thus varies, typically going from several millimeters in the central portion to only a few tenths of a millimeter (about 0.2 mm) at the ends of the tapering branches.

A reinforcing edge may be used to reinforce the leading edge or the trailing edge of a blade. It must therefore present a shape that matches its location, for example a shape that is twisted and cambered, being complementary to the shape of the edge of the blade body on which it is fastened.

Finally, on its outside face, a reinforcing edge needs to present a surface state that is smooth in order to avoid harming the aerodynamic properties of the blade, while on its inside face it needs to present a radius of curvature of good quality so as to be a close fit on the edge of the blade body on which it is fastened.

It is known, e.g. from patent application FR 2 961 866, to fabricate reinforcing edges by hot-shaping and machining a part made out of titanium alloy. The reinforcing edge is then assembled to the blade body, generally by adhesive, in order to form a blade. Nevertheless, the blade as obtained in that way can present cohesion that is insufficient. Under such circumstances, the stresses to which the blade is subjected can lead to the reinforcing edge separating from the blade body.

There therefore exists a real need for a fabrication method that is suitable for fabricating a reinforcing edge for a turbine engine blade that presents increased ability for cohesion with the blade body.

SUMMARY OF THE INVENTION

The present disclosure provides a fabrication method for fabricating a reinforcing edge of a turbine engine blade, the method comprising the following steps:

- providing a blank for the reinforcing edge;
- imprinting an indentation in said blank so as to form a rough surface.

The blank of the reinforcing edge may be forged or machined before or after the step of imprinting the indentation. The forging or machining may include steps of cambering, ramming, extrusion, or any combination of these three operations. The blank is generally a part made of titanium alloy.

In the present disclosure, the term "rough surface" is used to designate the surface that is specifically modified by the step of imprinting the indentation. Thus, the rough surface designates exclusively the imprinted surface, even though the blank may present other surfaces that are not imprinted but that nevertheless present a degree of roughness. When the blank is imprinted in a plurality of locations, the term "rough surface" may also cover all of the imprinted surfaces, whether or not they are contiguous.

The rough surface is the surface for assembling to a blade body, e.g. by adhesive, once the blank has been fully shaped in order to obtain a reinforcing edge. The method thus serves to optimize the surface state of the blank on its portion that is to receive adhesive, i.e. its rough surface, so as to improve its cohesion with the blade body. The ability of the blade to withstand stresses in the reinforcing edge is thus increased by the method.

Furthermore, because of its small number of steps, the method can easily be incorporated in a production line. The method is therefore not onerous to implement industrially.

In some embodiments, the method includes an additional step consisting in deforming at least the rough surface of the blank so as to obtain the final shape of the reinforcing edge.

In such embodiments, the rough surface is deformed after the step of imprinting the indentation. The method is thus particularly advantageous for use with a reinforcing edge on which it would not be possible to imprint a rough surface if it were already in its final shape.

In some embodiments, the blank has a profile that is generally Y-shaped.

The blank thus extends in a longitudinal direction and its profile is seen transversely to that direction. The profile of the blank may comprise a thick central base from which two generally tapering branches extend. The central base may present one or more curves relative to the longitudinal direction.

In some embodiments, the rough surface is situated inside of the blank.

The term "inside of the blank" designates the surface that is to come into contact with the blade body, which body is generally received in a recess provided in the reinforcing edge. When the blank has a profile that is generally Y-shaped, the inside of the blank designates the surface situated between the top branches of the Y-shape, i.e. the surface defined by the facing sides of the branches of the Y-shape.

In some embodiments, the rough surface is imprinted inside the Y-shape blank and the branches of the blank are then deformed and/or moved towards each other. By such a method, the step of imprinting the indentation is performed while the branches are sufficiently spaced apart and while it is relatively simple to pass an imprinting tool. In certain circumstances, after the branches have been moved towards each other, the zone including the rough surface may be inaccessible to machining tools and imprinting the indentation is then impossible.

In certain embodiments, the imprinting step is performed by die-stamping between a first die and a second die, at least one of the two dies including a punch configured to imprint said indentation.

In certain embodiments, the punch is provided on a side of the surface of the blank which have the indentation imprinted therein. The punch thus possesses an indentation that is complementary to the indentation desired for the rough surface. In particular, the punch may present a degree of roughness that makes it possible to obtain the desired roughness for the rough surface. The roughness of the punch may be substantially equal to the roughness desired for the rough surface.

The roughness of the rough surface is created by the initial roughness of the blank, by transferring roughness from the punch, and by die-stamping contingencies (loss of roughness on imprinting, materials characteristics, etc.).

Other methods of imprinting, such as chemical machining, cover a narrow range of roughness and require the blank to be prepared in order to protect those surfaces that are not to be imprinted. In contrast, die-stamping makes it possible to imprint an indentation in a manner that is selective and localized, without any need to protect the other surfaces of the blank.

The roughnesses that can be achieved by die-stamping cover a wide range. In addition, once the punch has been made, die-stamping is an operation that is faster, more repetitive, and less expensive than chemical machining.

In some embodiments, the roughness of the rough surface lies in the range 1 to 20, and preferably in the range 3 to 10.

In the present disclosure, the term "roughness" designates the magnitude satisfying the following definition. Profiles of the rough surface are obtained by sectioning said surface on a plane, and the roughness of the rough surface is defined as the mean of the roughnesses of the profiles of said surface. The roughness of a profile is defined by the arithmetical mean deviations from the mean line, and is often written Ra. The value Ra as calculated over a defined evaluation length for which the profile is continuous, is equal to the arithmetical mean absolute values of the distances between each point of the continuous profile and a mean line of said profile over the evaluation length under consideration. By convention, roughness values Ra are expressed in micrometers (μm), and the unit is not stated.

The above-mentioned ranges of values ensure that the rough surface has an optimum surface state for being assembled with a blade body.

The present disclosure also relates to a fabrication method for fabricating a turbine engine blade, the method comprising the following steps:

- providing a reinforcing edge made using the above-mentioned fabrication method;
- providing a blade body; and
- adhesively bonding all or part of the rough surface of the reinforcing edge to the blade body.

A turbine engine blade fabricated by this method may naturally have one or more reinforcing edges. For example, it may have two reinforcing edges, one acting as a leading edge and the other as a trailing edge.

A turbine engine blade fabricated by this method is particularly robust against stresses of all types, and in particular mechanical stresses. It presents increased cohesion between its reinforcing edge and its blade body.

In some embodiments, the blade body is made of organic matrix composite material. By way of example, it may be a composite blade body obtained by draping a woven material or by three-dimensional weaving. Still by way of example, the composite material used may be made by assembling woven carbon/plastics fibers with a resin matrix (e.g. a matrix made of epoxy, bismaleimide, or cyanate-ester resin), which assembly may be formed by means of a vacuum method of resin injection of the resin transfer molding (RTM) type.

The present disclosure also provides a turbine engine blade reinforcing edge having a surface, and in particular an inside surface, of roughness lying in the range 1 to 20, and preferably in the range 3 to 10.

Such a reinforcing edge thus presents a rough surface that is particularly suitable for assembling it to a blade body, as explained above.

In some embodiments, the reinforcing edge may present a Y-shaped profile as defined above. In certain embodiments, the rough surface may be on the inside of the reinforcing edge, i.e. the rough surface may correspond to all or part of the inside surface of the reinforcing edge.

The present disclosure also relates to a turbine engine blade including a reinforcing edge as described above. Such a turbine engine blade is particularly capable of withstanding stresses of all types, in particular mechanical stresses. It presents increased cohesion between the reinforcing edge and the blade body that makes it up.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its advantages can be better understood on reading the following detailed description of embodiments of the invention given as non-limiting examples. The description refers to the accompanying drawing, in which:

FIG. **1** is a perspective view of a blank for leading edge reinforcement;

FIG. **2** is a diagram showing the step of imprinting an indentation on the blank;

FIG. **3** is a perspective view of a reinforcing edge after deformation; and

FIG. **4** is a fragmentary section view of a turbine engine blade.

FIG. **1** is a perspective view of an example of a blank **10** used for fabricating a reinforcing edge. In this example, the blank **10** is generally Y-shaped. Specifically, it has a central portion **40** of considerable thickness and two tapering branches **20** and **30** of smaller thickness. The central portion **40** extends in a longitudinal direction. It may present one or more curves in this longitudinal direction. The right branch **20** and the left branch **30** extend from the central portion **40**.

The terms "left" and "right" are used solely with reference to the drawings, for reasons of clarity, and say nothing about the direction in which the blank is finally used.

The right branch **20** and the left branch **30** each have a respective inside face **22**, **32** and a respective outside face **24**, **34**. The inside faces **22** and **32** face each other; in other words, the inside faces **22** and **32** form between them a salient angle, i.e. an angle of less than 180°.

During the method of fabricating the reinforcing edge, a rough surface is imprinted on the blank **10**. For example, this imprinting may be performed by die-stamping. Such a die-stamping step is shown diagrammatically in FIG. **2**. The blank **10** is placed between a first die **50** and a second die **52**. The first die **50** has a first bearing surface **56** of shape complementary to the shape of the outside faces **24** and **34** and of the central portion **40** of the blank. The second die **52** has a punch **54** that is defined by a second bearing surface **58** of shape that is complementary to the shape of the inside faces **22** and **32**. Thus, when the dies **50** and **52** are moved towards each other in order to press against the blank **10**, the overall shape of the blank **10** is unchanged.

In this embodiment, the second bearing surface **58** of the punch **54** possesses an indentation that is complementary to the indentation it is desired to transfer by imprinting the inside of the blank. The inside of the blank is used to mean all or part of the inside faces **22** and **32**. For example, the indentation of the second bearing surface **58** may merely be a surface of selected roughness. Furthermore, it is clear that if it is desired to imprint an indentation on the outside of the blank **10**, e.g. on the outside faces **24** and **34**, then it is the first bearing surface **56** rather than the second bearing surface **58** that needs to present an appropriate indentation.

Preferably, the step of die-stamping the blank **10** is performed under heat, i.e. during die-stamping, the blank **10** is at a temperature that is high enough to facilitate transferring the impression of the indentation. When using a titanium alloy, the temperature used for this step may for example be about 600° C.

By way of example, the punch **54** may be designed to be removable, so that it suffices to change the punch on a given die in order to change the type of indentation or in order to change the value of the imprinted roughness.

Furthermore, the surface of the punch **54** may be prepared by milling, in particular using a ball bur. Under such circumstances, adjusting the pitch of the milling determines the desired roughness dimension. At the end of the die-stamping step, the overall shape of the blank **10** remains unchanged but the blank **10** presents a rough surface S over all or part of its inside faces **22** and **32**. The rough surface S imprinted by the second bearing surface **58** of the punch **54** presents the desired roughness.

Thereafter, the blank **10** may be deformed so that it reaches its final configuration of a reinforcing edge **10'**. Such a reinforcing edge **10'** is shown in FIG. **3**. Specifically, the deformed portions of the blank include the rough surface S carried by the inside faces **22** and **32**. The deformation methods that can be used are well known to the person skilled in the art.

After deformation, the inside faces **22** and **32** may also be moved closer to each other than they were in the original blank (cf. FIG. **1**). In the example of FIG. **3**, they are almost parallel. The space defined between the inside faces **22** and **32** is small, which is why such a deformation operation is sometimes referred to as "closing". Furthermore, the reinforcing edge **10'** is substantially more cambered and twisted in the longitudinal direction than was the blank **10**.

It should be observed that it would be difficult to perform the above-described die-stamping step on a blank **10** having the final shape of the reinforcing edge **10'**, for at least the following reasons: firstly even assuming that inserting a punch **54** into the inside of the blank **10** were possible in spite of the inside of the blank being narrow, it would still be necessary to provide a punch **54** that is thin and cambered, which would be difficult to construct. Secondly, insofar as the force exerted for die-stamping acts only by its component that is locally normal to the surface of the blank **10**, it would be necessary to press with a force that increases with increasing closure of the profile of the blank **10**, i.e. the force would need to be greater when the branches **20** and **30** are close to each other.

The fabrication of a turbine engine blade may include providing a reinforcing edge **10'** fabricated using the above-described method. For example, this reinforcing edge **10'** may be a leading edge. As shown in FIG. **4**, which is a fragmentary section view of a turbine engine blade **70**, the reinforcing edge is subsequently assembled onto a blade body **60** that is configured to receive it. In other words, the outside shape of the blade body **60** may be complementary to the shape of the inside faces **22** and **32** of the reinforcing edge **10'** so that they fit together perfectly. Bonding takes place via the rough surface S, and in particular it may be achieved by adhesive.

More precisely, the blade body **60** has a suction side face **62** and a pressure side face **63**. The right inside surface **22** is adhesively bonded via its rough surface S to the suction side face **62**, while the left inside surface **32** is adhesively bonded via its rough surface S to the pressure side face **63**. The roughness of the rough surface S provides good cohesion of the adhesive between the reinforcing edge **10'** and the blade body **60**.

Although the present invention is described with reference to specific embodiments, modifications may be made to those embodiments without going beyond the general scope of the invention as defined by the claims. In particular, the individual characteristics of the various embodiments that are shown and/or mentioned may be combined in additional embodiments. Consequently, the description and the drawings should be considered in a sense that is illustrative rather than restrictive.

The invention claimed is:

1. A fabrication method for fabricating a reinforcing edge of a turbine engine blade, the method comprising the following steps:

providing a blank for the reinforcing edge; and

imprinting an indentation in said blank by die-stamping between a first die and a second die, wherein one of the first die or the second die includes a first rough surface, so as to form a second rough surface on the blank, at least one of the two dies including a punch configured to imprint said indentation, wherein the blank has a substantially Y-shape before the imprinting step.

2. The fabrication method as claimed in claim **1**, including an additional step consisting in deforming at least the second rough surface of the blank so as to obtain the final shape of the reinforcing edge.

3. The fabrication method as claimed in claim **2**, wherein the blank has a profile that is generally Y-shaped.

4. The fabrication method as claimed in claim **2**, wherein the second rough surface is situated on the inside of the blank.

5. The fabrication method as claimed in claim **2**, wherein the roughness of the second rough surface lies in the range 1 to 20.

6. The fabrication method as claimed in claim **1**, wherein the blank has a profile that is generally Y-shaped.

7. The fabrication method as claimed in claim **1**, wherein the second rough surface is situated on the inside of the blank.

8. The fabrication method as claimed in claim **1**, wherein the roughness of the second rough surface lies in the range 1 to 20.

9. The fabrication method as claimed in claim **1**, wherein the roughness of the second rough surface lies in the range 3 to 10.

10. The fabrication method as claimed in claim **1**, wherein the substantially Y-shape of the blank has a diverging inside portion, and the imprinting step includes forming the second rough surface on the diverging inside portion of the blank.

11. The fabrication method as claimed in claim **1**, wherein the substantially Y-shape of the blank has a diverging inside portion before the imprinting step, the imprinting step includes forming the second rough surface on the diverging inside portion of the blank, and the imprinting step includes forming the second rough surface on the blank without changing an overall shape of the blank.

12. A fabrication method for fabricating a turbine engine blade, the method comprising the following steps:

providing a reinforcing edge made using the fabrication method as claimed in claim **1**;

providing a blade body; and

adhesively bonding all or part of the second rough surface of the reinforcing edge to the blade body.

13. The fabrication method as claimed in claim **12**, wherein the blade body is made of organic matrix composite material.

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